Entergy®

**Entergy Operations, Inc.**
1448 S.R. 333
Russellville, AR 72802

**Timothy L. Arnold**
Manager, Regulatory Assurance
Arkansas Nuclear One
Tel 479-858-7826

10 CFR 50.73

2CAN071901
July 23, 2019

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555

Subject: Licensee Event Report 50-368/2019-001-00
Reactor Trip Due to a Reactor Coolant Pump Motor Failure

Arkansas Nuclear One, Unit 2
NRC Docket No. 50-368
Renewed Facility Operating License No. NPF-6

Pursuant to the reporting requirements of 10 CFR 50.73, attached is the subject Licensee Event Report 50-368/2019-001-00 concerning the reactor trip due to a reactor coolant pump motor failure at Arkansas Nuclear One, Unit 2.

This letter contains no new regulatory commitments.

Should you have any questions concerning this issue, please contact Tim Arnold, Manager, Regulatory Assurance, at 479-858-7826.

Sincerely,

**ORIGINAL SIGNED BY TIMOTHY L. ARNOLD**

TLA/ble

Attachment: Licensee Event Report 50-368/2019-001-00

cc: Mr. Scott A. Morris
Regional Administrator
U. S. Nuclear Regulatory Commission
Region IV
1600 East Lamar Boulevard
Arlington, TX 76011-4511

NRC Senior Resident Inspector
Arkansas Nuclear One
P.O. Box 310
London, AR 72847

Institute of Nuclear Power Operations
700 Galleria Parkway
Atlanta, GA 30339-5957
LEREvents@inpo.org

NRC FORM 366
(04-2018)

U.S. NUCLEAR REGULATORY COMMISSION

# LICENSEE EVENT REPORT (LER)

(See Page 2 for required number of digits/characters for each block)

(See NUREG-1022, R.3 for instruction and guidance for completing this form http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1022/r3/)

APPROVED BY OMB: NO. 3150-0104 EXPIRES: 03/31/2020

Estimated burden per response to comply with this mandatory collection request: 80 hours. Reported lessons learned are incorporated into the licensing process and fed back to industry. Send comments regarding burden estimate to the Information Services Branch (T-2 F43), U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, or by e-mail to Infocollects.Resource@nrc.gov, and to the Desk Officer, Office of Information and Regulatory Affairs, NEOB-10202, (3150-0104), Office of Management and Budget, Washington, DC 20503. If a means used to impose an information collection does not display a currently valid OMB control number, the NRC may not conduct or sponsor, and a person is not required to respond to, the information collection.

| 1. Facility Name | 2. Docket Number | 3. Page |
|---|---|---|
| Arkansas Nuclear One Unit 2 | 05000368 | 1 OF 5 |

**4. Title**

## Reactor Trip due to a Reactor Coolant Pump Motor Failure

| 5. Event Date | | | 6. LER Number | | | 7. Report Date | | | 8. Other Facility Involved | |
|---|---|---|---|---|---|---|---|---|---|---|
| Month | Day | Year | Year | Sequential Number | Rev No. | Month | Day | Year | Facility Name | Docket Number |
| | | | | | | | | | N/A | N/A |
| 05 | 26 | 2019 | 2019 | - 01 | - 00 | 07 | 23 | 2019 | Facility Name N/A | Docket Number N/A |

| 9. Operating Mode | 11. This Report is Submitted Pursuant to the Requirements of 10 CFR §: *(Check all that apply)* | | | |
|---|---|---|---|---|
| 1 | ☐ 20.2201(b) | ☐ 20.2203(a)(3)(i) | ☐ 50.73(a)(2)(ii)(A) | ☐ 50.73(a)(2)(viii)(A) |
| | ☐ 20.2201(d) | ☐ 20.2203(a)(3)(ii) | ☐ 50.73(a)(2)(ii)(B) | ☐ 50.73(a)(2)(viii)(B) |
| | ☐ 20.2203(a)(1) | ☐ 20.2203(a)(4) | ☐ 50.73(a)(2)(iii) | ☐ 50.73(a)(2)(ix)(A) |
| | ☐ 20.2203(a)(2)(i) | ☐ 50.36(c)(1)(i)(A) | ☒ 50.73(a)(2)(iv)(A) | ☐ 50.73(a)(2)(x) |
| **10. Power Level** | ☐ 20.2203(a)(2)(ii) | ☐ 50.36(c)(1)(ii)(A) | ☐ 50.73(a)(2)(v)(A) | ☐ 73.71(a)(4) |
| 100% | ☐ 20.2203(a)(2)(iii) | ☐ 50.36(c)(2) | ☐ 50.73(a)(2)(v)(B) | ☐ 73.71(a)(5) |
| | ☐ 20.2203(a)(2)(iv) | ☐ 50.46(a)(3)(ii) | ☐ 50.73(a)(2)(v)(C) | ☐ 73.77(a)(1) |
| | ☐ 20.2203(a)(2)(v) | ☐ 50.73(a)(2)(i)(A) | ☐ 50.73(a)(2)(v)(D) | ☐ 73.77(a)(2)(i) |
| | ☐ 20.2203(a)(2)(vi) | ☐ 50.73(a)(2)(i)(B) | ☐ 50.73(a)(2)(vii) | ☐ 73.77(a)(2)(ii) |
| | | ☐ 50.73(a)(2)(i)(C) | ☐ Other (Specify in Abstract below or in NRC Form 366A) | |

**12. Licensee Contact for this LER**

| Licensee Contact | Telephone Number (Include Area Code) |
|---|---|
| Benjamin Lee Egnew | 479-747-1258 |

**13. Complete One Line for each Component Failure Described in this Report**

| Cause | System | Component | Manufacturer | Reportable to ICES | Cause | System | Component | Manufacturer | Reportable to ICES |
|---|---|---|---|---|---|---|---|---|---|
| B | AB | MO | G080 | Yes | | | | | |

| 14. Supplemental Report Expected | 15. Expected Submission Date | Month | Day | Year |
|---|---|---|---|---|
| ☐ Yes (If yes, complete 15. Expected Submission Date) ☒ No | | | | |


**Abstract** (Limit to 1400 spaces, i.e., approximately 14 single-spaced typewritten lines)

On May 26, 2019, the Arkansas Nuclear One, Unit 2 (ANO-2), reactor automatically tripped due to a fault and subsequent trip of Reactor Coolant Pump (RCP) 2P-32B.

The direct cause of the event was determined to be the loss of stator core compression coupled with broken compression finger welds allowing a finger to migrate into contact with the RCP rotor. The broken finger plate section damaged the stator insulation resulting in a short to ground.

The plant transient led to an automatic reactor trip due to a Plant Protection System actuation. After the reactor trip, the unit was stabilized in Mode 3 with Emergency Feedwater (EFW) initially being used to maintain plant temperature under automatic control.

| 1. FACILITY NAME | 2. DOCKET NUMBER | 3. LER NUMBER | | |
|---|---|---|---|---|
| | | YEAR | SEQUENTIAL NUMBER | REV NO. |
| Arkansas Nuclear One Unit 2 | 05000-368 | 2019 | - 001 | - 00 |

**NARRATIVE**

## A. PLANT STATUS

At the time of the event, ANO-2 was operating at 100% rated thermal power in Mode 1. There were no other structures, systems, or components (SSCs) that were inoperable at the time contributing to the event.

## B. BACKGROUND

ANO-2 experienced failure of the 2P-32B Reactor Coolant Pump (RCP) motor on May 26, 2019. The motor failed with a phase-to-ground fault and examination of the failed stator identified that one of the compression fingers had come loose and migrated into contact with the rotor, damaging the stator coil insulation. Subsequent research identified that a similar failure mechanism occurred in 1979 on an ANO-2 RCP. General Electric (GE) subsequently modified all four RCP motors with mitigating strategies that included welding at several locations and the addition of epoxy impregnated felt around the fingers to prevent vibration.

The failed motor had been refurbished with new windings and stator laminations by Framatome and was installed at the 2P-32B location in 2015.

## C. DESCRIPTION OF EVENT

The ANO-2 reactor tripped at 0512 on May 26, 2019, due to loss of the 2P-32B RCP. Following the loss of the RCP, a field operator reported that a drop flag indicator had fallen on 6900 Volt Switchgear 2H-21 'B' RCP breaker indicating a ground fault had occurred. The reactor tripped upon loss of the RCP as designed and all systems performed as expected.

During the plant transient the Emergency Feedwater System (EFW) [HHJ] actuated and provided water to the "B" Steam Generator. This is a normal response to the loss of one RCP in one of the two Reactor Coolant System loops. The EFW system was secured at 1003 on May 26, 2019.

A Failure Modes Analysis team was formed to determine the cause of the RCP failure. The investigation determined that the "B" phase motor winding indicated zero mega-ohms to ground. Further resistance measurements found the "B" phase had 232 ohms to ground, which is essentially a shorted condition of that phase. Testing was conducted from the breaker and locally at the motor which determined that the condition was inside the motor at the windings. All conductors in the motor junction box were inspected with no issues found. Borescope inspections of the brazed link bars behind the junction box were also conducted with no issues noted. These inspections determined the problem to be inside the motor in one of the “B” phase coils.

The motor was removed from the Containment Building and sent to the vendor facility for further inspection and repair. At the facility, the rotor was pulled and the stator inspected. Inspection revealed the phase-to-ground fault was caused by stator insulation damage which was, in turn, caused by a loose compression finger that migrated into the air gap between the stator and rotor, making contact with the rotor while in operation. The rub on the rotor moved the loose finger into the coil, damaging the insulation.

During the course of the investigation, it was determined that previous issues with the motors had been identified in 1979 which were directly related to the current deficiency. Correspondence from GE during the 1979 time frame identified the issue of loose compression fingers which resulted in the 1979 motor failure. The correspondence also discussed the GE recommended mitigating strategy. The correction was completed on all four ANO-2 RCP motors in 1979. The 1979 issue and mitigation strategy were not documented in any motor specifications or operating experience.

The inspection of the failed motor at the vendor facility identified multiple broken spot welds between fingers and the compression ring, and multiple loose fingers. A second focused Failure Modes Analysis was jointly conducted by Entergy, the vendor, and other industry personnel. This analysis determined the GE RCP motors at ANO-2 had a fundamental design flaw which allows the core compression to be lost in the motors and/or compression finger loosening. This design issue was acknowledged in Combustion Engineering letter A-CE-7419. The loss of compression in the motor core may occur when the core cradle is welded into the motor housing or during operation as a result of starts and stops and lack of stiffness in some part of the clamping system. The loss of compression allows the fingers under the compression ring to become loose. Inspection of the broken weld on a finger by the vendor's metallurgist via scanning electron microscopy, found that the weld failed due to bending stress (overload) and was not caused by vibration fatigue. The cracking of the finger welds and lack of core compression (clamping the fingers) allows finger movement and subsequent contact with the rotor. Contact with the rotor pushed a finger into contact with the coil insulation, causing damage, and resulting in a phase-to ground fault.

There are 108 fingers (in segmented groups of 12) under each upper and lower compression ring. Twelve (12) fingers are weld mounted to each finger plate segment. Each finger is then welded to the compression ring. In the original pre-1979 design, the fingers were not welded to the compression plate, relying only on core compression to hold the fingers and the finger plate in place. In order for a finger to migrate into contact with the rotor, a sufficient number of finger welds to the compression ring must fail to allow the entire finger plate to migrate forward, or the finger weld must be cracked allowing the finger to vibrate and fatigue the finger plate, causing the plate to crack and break and allowing that finger to move forward. The Failure Modes Analysis team determined this later scenario to be the cause of failure.

## D. EVENT CAUSES

The direct cause of this event was loss of stator core compression coupled with broken compression finger welds, allowing a finger to migrate into contact with the RCP rotor. The broken finger plate section under the finger damaged the stator insulation resulting in a short-to-ground.

A contributing cause was identified as inadequate design of the original GE motor. The original design flaw allowed the core to become un-compressed during motor operation resulting in loose compression fingers. This is supported by GE correspondence identified in historical ANO files. GE efforts to correct the condition resulted in mitigating actions that supported more than 30 years of satisfactory service.

A second contributing cause was determined to be associated with organizational weakness in that the GE mitigating actions and related operating experience was not replicated in ANO motor specifications or operating experience documents. The epoxy felt around the fingers and between the coils was noted in initial inspections at Westinghouse and later at Framatome. However, use of the epoxy felt was not employed in future motor refurbishments due to misunderstanding of the purpose of this mitigation strategy.

E. CORRECTIVE ACTIONS

The following action has been completed:

A visual Inspection by Entergy personnel during motor assembly was performed and documented to verify the presence of felt around the compression fingers.

An Extent of Condition was performed on the remaining RCPs and found no adverse condition to preclude restart of ANO-2.

The following action is scheduled to be completed during motor reassembly, prior to reinstallation:

Enhanced core clamping actions defined in the supporting vendor document will be performed on the new stator being manufactured.

The following action is currently scheduled to be completed during the fall 2019:

The motor specification or applicable documents provided to applicable vendors will be revised which will require the reporting of all deficiencies found during initial inspections to site personnel.

Additional actions are included in ANO's Corrective Action Program.

F. SAFETY CONSEQUENCES

No safety consequences where noted for this event. All systems responded as designed upon loss of the affected RCP.

G. BASIS FOR REPORTIBILITY

This event is reportable pursuant to the following criteria.

10 CFR 50.73(a)(2)(iv)(A) requires manual or automatic actuations of systems listed in 10 CFR 50.73(a)(2)(iv)(B) to be reported. The guidance provided in NUREG 1022 states under 10 CFR 50.73(a)(2)(iv)(B)(6):

*PWR auxiliary or emergency feedwater system.*

Event Notification 54091 was made on May 26, 2019.

Because the ANO-2 EFW system actuated during this event, the aforementioned reporting criteria is relevant.

H. ADDITIONAL INFORMATION

A review of the ANO Corrective Action Program and Licensee Event Reports for the previous three years was performed. No relevant similar events were identified.

Energy Industry Identification System (EIIS) codes and component codes are identified in the text of this report as [XX].